

**LOW-VELOCITY SPALL TESTING OF TI-6AL-4V ALLOY
AND NEW SPALL CRITERION BASED ON MESOSCALE**

Second interim Report
(Sept.17/2002 – Dec.16/2002)

Principal Investigator: J.R.KLEPACZKO

**UNITED STATES ARMY EUROPEAN RESEARCH OFFICE
LONDON, UK**

CONTRACT N°: N62558-02-M-5857
R&D 9314-AN-01

Contractor:

Laboratory of Physics and Mechanics of Materials
ISGMP, UMR – CNRS 7554
METZ UNIVERSITY
F-57045 Metz, France

Approved for public release
Distribution unlimited

20030317 079

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204 Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE December 17 / 2002	3. REPORT TYPE AND DATES COVERED Second INTERIM, September 17 / 2002 - December 16 / 2002		
4. TITLE AND SUBTITLE EFFECTS OF IMPACT VELOCITY AND STRESS CONCENTRATORS IN TITANIUM ALLOYS ON FAILURE BY ADIABATIC SHEARING			5. FUNDING NUMBERS N68171-00-M-5984	
6. AUTHOR(S) J.R. KLEPACZKO				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) METZ UNIVERSITY - ISGMP LAB. OF PHYSICS AND MECHANICS OF MATERIALS ILE DU SAULCY, F-57045 METZ cedex 1, FRANCE			8. PERFORMING ORGANIZATION REPORT NUMBER N/A	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) USA RDSG-UK, AERONAUTICS AND MECHANICS BRANCH Dr. Sam SAMPATH 223 OLD MARYLEBONE RD. LONDON NW1-5TH, U.K.			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT DISTRIBUTION UNLIMITED			12b. DISTRIBUTION CODE N/A	
13. ABSTRACT (Maximum 200 words) This Interim Report covers the contract period from Sept. 17/2002 to Dec. 16/2003 (the second period of three months). The research in this Project is directed toward better understanding of the fracture process due to the local plastic fields occurring in mesoscale during spalling of Ti-6Al-4V alloy. Preliminary planar impact tests have been performed using specimens in the form of disks of different thickness and DIA 57.0 mm delivered by AMSRL-WM-TA, APG Aberdeen, MD. The plate-plate facility is in the stage of functioning after some period of preparation. A methodology of observation of the fracture surfaces after spalling on the mesoscale has been prepared. More exactly, the surface topography after spall fracture has already been analyzed for an aluminum alloy (preliminary analysis) and some statistics programs were tested. A new, high resolution profilometer, based on the light interference: WYKO NT1000 by VEECO has been applied in this part of the Project. The profilometer is equipped with a software which permits for variety of statistical analyses. This software permits for a detailed analysis of profiles in 3D. The 3D profiles will be compared with the scanning microscope data for the same areas. An additional series of the improved Direct Impact Shear Test has been performed for Ti-6Al-4V alloy. The test results obtained from DIST at high strain rates $\sim 10^3$ 1/s will be applied to identify the material constants in new temperature coupled model of spalling based on mesoscale..				
14. SUBJECTS ITEMS ADIABATIC SHEAR BANDS, TITANIUM ALLOY Ti-6Al-4V, STRESS CONCENTRATORS IN IMPACT, DYNAMIC PLASTICITY			15. NUMBER OF PAGES 01	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102

EXTENDED ABSTRACT

During the second period (three months from Sept.17/2002 to Dec.16/2002) of the Contract the technical objective was to improve all the experimental setups and to put into operation the planar impact facility (impact plate on plate) and to perform preliminary tests with Ti-6Al-4V alloy. In addition, the Modified Double Shear experiments, [1], by direct impact have been continued for the same Ti alloy with an improved method of specimen attachment. The main purpose of this research is to clarify, using spall experiments, the role of short-time local plastic fields occurring in the meso-scale in material failure at very short time intervals. The thermal coupling and the local high strain rates will be considered in the modeling.

The Laboratory of Physics and Mechanics of Materials is equipped, besides Hopkinson bars in compression and torsion, in the plate impact facility with bore diameter 57 mm. A flyer plate can be accelerated up to 800 m/s depending on the gas that is used. A series of preliminary spall tests have been performed at different target/flyer thickness and different impact velocities. A critical minimal impact velocity was sought when the incipient spall occurs at loading times from ~600 ns to ~2.5 μ s. The specimens in the form of disks of different thickness and DIA 57 mm have been delivered by AMSRL-WM-TA, APG Aberdeen, MD.

An observation of the spalled surfaces of Ti-6Al-4V is in preparation, more exactly the surface topography in 3D. The new, high resolution profilometer, based on the light interference: WYKO NT1000 by VEECO, has been applied to determine 3D surface characteristics for an Al alloy as a preliminary study. This profilometers is equipped in a sophisticated software which has been already tested. The software permits for a detailed analysis of the surface profiles in 3D including statistics.

After previous research projects on Ti-6Al-4V supported by the European Research Office of the US Army an ample data are available obtained via the fast shearing, including additional tests performed recently, which will permit to identify all material constants in a constitutive relation developed in LPMMP.

Our recent works toward understanding fracture in the meso-scale constitute a base for further studies. A new mesoscale model of fracture has already been applied to armor steels and hard aluminum alloy, [2,3]. The new model of spall fracture will be applied for Ti-6Al-4V based on the plate impact experiments, microscopic observations and topography analysis.

References

- [1] J.R.Klepaczko, An Experimental Technique for Shear Testing at High and Very High Strain Rates. The Case of a Mild Steel, *Int. J. Impact Engng.*, **15** (1994), 25.
- [2] P.Chevrier and J.R.Klepaczko, Spall fracture, mechanical and microstructural aspects, *Eng. Fract. Mech.*, **63** (1999), 273.
- [3] J.R.Klepaczko and P.Chevrier, Fracture dynamics in one-dimensional strain, in: *Modeling of Damage and Fracture Processes in Engineering Materials*, IFTR, Warsaw, Poland, (1999), 90.

Research reported in this document has been made possible through the support and sponsorship of the US Government through its European Research Office of the US Army. This Interim Report is intended only for the internal management use of the Contractor and the US Government.